Subcategories and Preliminary MACT Floor Determination for Gas, Distillate Oil and Residual Oil Fired Boilers

Boiler Work Group

Of the

Industrial Combustion Coordinated Rulemaking (ICCR)

Federal Advisory Committee

September 3, 1998

Subcategories and Preliminary MACT Floor Determination for Gas, Distillate Oil and Residual Oil Fired Boilers

Contents

Executive Summary

The Boiler Work Group (BWG) reached consensus that, based on the data reviewed and the assumptions identified below, no MACT Floor can be identified at this time for oil and gas. In this discussion and presentation, No MACT Floor means:

- No group corresponding to the best performing 12% of existing sources could be identified by reviewing the following information:
  - Existing add-on controls that may reduce HAPs
  - Existing emissions data, air regulations, and air permit limitations for HAPs

That is, NO MACT FLOOR FOR OIL AND GAS FIRED BOILERS.

However, the BWG did not reach consensus on whether:

- Good combustion practice (GCP) should be incorporated into the MACT Floor at this time and,
- Gaseous fuel derived from the processing of crude oil, petroleum or petrochemicals should be categorized with natural gas.

EPA should further consider how these two issues and other issues affect MACT floor determinations, if at all.

The Boiler Work Group (BWG) has determined subcategories for natural gas, oil (distillate and residual) and coal fossil fuel fired boilers. Further, it has identified the MACT floor for gas and oil fossil fuel fired boilers. The BWG recommends that the Coordinating Committee of the ICCR FACA forward these determinations and associated rationale to the EPA.

Fossil Fuel Fired Boiler Subcategories

The BWG has determined that the following subcategories should be used for fossil fuel fired boilers:

- Natural Gas (Includes wellhead gas, pipeline gas, LPG) NOTE: there was not a BWG consensus to include Gaseous Fuels derived from processing of crude oil, petroleum or petrochemicals in the Natural Gas subcategory
- Oils
  - Unheated or Distillate Oils
  - Heated or Residual Oils
- Coal (Solid Fossil Fuel)

- Fluidized Bed Boilers which would be further divided into the following fuel groups:
  - Anthracite, Bituminous, Subbituminous, Lignite, Petroleum Coke

- Mass Fired / Stoker Boilers which would be further divided into the following fuel groups:
  - Anthracite, Bituminous, Subbituminous, Lignite

- Pulverized / Cyclone Boilers which would be further divided into the following fuel groups:
  - Anthracite, Bituminous, Subbituminous, Lignite, Petroleum Coke

The workgroup determined for coal that to describe boilers by firing type and then by fuel type was necessary to encompass the different combinations that may have an effect on HAP emissions.

The BWG recommends that the ICCR Coordinating Committee forward to the EPA these subcategories for the above listed fuel groups. The BWG recognizes that the final subcategories for any MACT standards established for existing fossil fuels may be different than those established for the purposes of a final MACT floor regulation since other information and data reviews may occur between now and the final rule.

MACT Floors for Fossil Fuel Boilers

The BWG reached consensus on MACT Floors for the gas and oil fossil fuel fired boilers in the subcategories stated above. The BWG reached consensus that based on the data reviewed and the assumptions shown in this document, NO MACT FLOOR can be identified at this time for oil and gas fired boilers.

MACT floors for solid fossil fuel (coal) boilers were not fully developed by the boiler workgroup. The floors will probably include some form of particulate control. Further evaluation of both the emission database and inventory database is needed to determine what the floors should be.

The BWG recommends that the Coordinating Committee forward this NO MACT FLOOR determination for oil and gas to the EPA.

Rationale for Fossil Fuel Subcategories

Natural Gas Boilers

Basically Natural Gas Boilers (including wellhead gas, pipeline gas, LPG, and Gaseous Fuels Derived from processing of crude oil, petroleum or petrochemicals) have similar burner design. Whether fire tube or water tube boilers, combustion characteristics for HAPs were assumed to be defined by the fuel rather than the burner.

Oil Fired Boilers

Like gas fired boilers, the preponderance of oil fired boilers have similarly designed burners. In general they atomize the fuel into the firing chamber by means of steam, air or a mechanical device. Again, like gas, the combustion process is fuel dependent rather than boiler dependent. Therefore, oil fired systems were divided into two subcategories: distillate (unheated) oil and residual (heated) oil.

Coal Fired Boilers

For the solid fossil fuel fired boilers two main factors were considered for the subcategories. These were basic boiler design and fuel type. The boiler designs were split into three basic firing types: pulverized / cyclone, mass fired, and fluidized bed. Each of these firing types could have an effect on HAP formation due to the differences in boiler and fuel feed design. After considering the firing type, the fuel type must be considered. The ASTM standard fuel definitions were used: anthracite, bituminous, subbituminous, and lignite. Petroleum coke was also considered as a fuel type. The fuel type also plays a key role in boiler design that could effect HAP formation and emissions.

Rationale for MACT Floor Determination

The BWG identified the MACT floors for existing natural gas and oil subcategories in accordance with the provisions for MACT included in Section 112(d) of the Clean Air Act, as amended in 1990. In order to identify the best performing group of sources and determine the MACT floors, the BWG reviewed the following available information related to control devices and HAPs emissions for existing boilers:

- Existing add-on controls that may reduce HAPs,
- Existing good combustion practices that may reduce HAPs,
- Existing emissions data, and
- Existing air regulations, air permits and RACT/BACT/LAER databases for HAPs limitations.

The BWG reviewed ICCR Inventory Database version 3.0 to assess the prevalence of existing add-on controls for gas and oil fired systems. The BWG determined that the average of the best performing 12 percent could be estimated by first assessing whether at least 6 percent of the boilers in a subcategory had add-on controls. Therefore, the BWG set its add-on control cutoff at 6 percent for oil and gas fired boilers. Using this cutoff standard, gas fired and oil (distillate and residual) fired systems did not have add-on controls in the database that exceeded the 6 percent level. The conclusion was that there was No MACT Floor for controls in these three subcategories.

MACT floors for controls for solid fossil fuel (coal) boilers were not fully developed by the boiler workgroup. The floors will probably include some form of particulate control. However, further evaluation of both the emission database and inventory database is needed to determine what the floors should be and whether or not it is appropriate for acid gas controls to be part of the floors.

The BWG also reviewed Good Combustion Practices (GCP) for gas and oil fired boiler systems. Issues like air/fuel ratios and maintenance practices were studied. However, based on the information reviewed thus far some of the Boiler Work Group believe that good combustion practices should not be included in the MACT Floor for existing gas or oil fired boilers. However, this was not a consensus decision. It was thought by some that combustion practices like air to fuel ratios may, in fact, concurrently control HAP emissions even though that may not have been the intended reason for the control.

Emission data was reviewed to determine if there were HAP limits that needed to be regulated for MACT floor purposes. The BWG reviewed the emissions database for boilers, state permit limits, state regulation limits and the RACT/BACT/LAER databases. The BWG concluded that based on the information in these databases there is insufficient information to identify a MACT floor for emission limits. Therefore, again, there is NO MACT FLOOR for the oil and gas subcategories. That is, there is insufficient information to establish HAP emission limitations or HAP emission reduction targets as a part of the MACT floor for these subcategories.

Subcategories and Preliminary MACT Floor Determination for Gas, Distillate Oil and Residual Oil Fired Boilers

1. Introduction

It was the Boiler Work Group's (BWG) intent to determine subcategories and thence the MACT Floors for those subcategories. The BWG determined the subcategories for natural gas, oil (distillate and residual) and coal fuels. The BWG was successful in determining a MACT Floor for natural gas and the oils. Further work will have to be done in order to determine the MACT floor for coal.

This paper documents the results of the processes to reach these conclusions. In general, the Fossil Fuel Subgroup performed the majority of the study and presented its results to the BWG. Consensus was obtained in the BWG with the exception of gaseous fuels derived from processing of crude oil, petroleum or petrochemicals being included in the definition of natural gas and the determination that there were no good combustion practices (GCP) that controlled HAPs.

Below is a description and discussion of the following topics that led to the final subcategorization and MACT floor determinations:

- Subcategorization methodology and rationale
- Review of the Boiler Inventory Database (V 3.0), state regulation and permit databases for MACT Floor control determination
- Review of the Emissions Database and state regulation and permit databases for HAP emission limit determination
- Review of Good Combustion Practices to determine if they could be considered in the MACT Floor determination.

2.0 Subcategories for Fossil Fuel Boilers

2.1. Key Definitions

There are several key definitions to be considered when beginning to subcategorize fossil fired boilers.

2.1.1 Boiler: Boiler means an enclosed device using controlled flame combustion and having the primary purpose of recovering and exporting useful thermal energy in the form of hot water, saturated steam or superheated steam. The principal components of a boiler are a burner, a firebox, a heat exchanger, and a means of creating and directing gas flow through the unit. A boiler's combustion chamber and primary energy recovery section(s) must be of integral design (i.e., the combustion chamber and the primary energy recovery section(s), such a as waterfall and superheaters, must be physically formed into one manufactured or unit assembled unit. (A unit in which the combustion chamber and the primary energy recovery section(s) are joined only by ducts or connections carrying flue gas is not integrally designed; however secondary energy recovery equipment (such as economizers or air preheaters) need not be physically formed into the same unit as the combustion chamber and the primary energy recovery section.) Only stand-alone boilers are covered by this definition; waste heat boilers, which are associated with stationary gas turbines or engines, are excluded. (From the *Regulatory Alternatives Paper* by the Incinerator Work Group submitted to the ICCR Coordinating Committee July, 1998.)

2.1.2 Natural gas: The natural gas category includes:

> -Standard Definition of Natural Gas: The definition for Natural Gas was taken from the NSPS Rules in 40 CFR 60.41 b: a naturally occurring mixture of hydrocarbon and non-hydrocarbon gases found in geologic formations beneath the earth's surface, of which the principal constituent is methane; or (2) liquid petroleum gas, as defined by the American Society for Testing and Materials in ASTM D1835-82, "Standard Specification for Liquid Petroleum Gases". For all practical purposes, natural gas includes wellhead gas which is gas straight from the ground containing principally methane, hydrogen, carbon and oxygen.
>
> -Liquid Petroleum Gas(LPG): LPG is propane and/or butane often with small amounts of propylene and butylene sold as a pressurized liquid. LPG is also used by boilers for ignition fuel and as a standby fuel. For purposes of the MACT Floor determination, LPG is included with natural gas as given in the definition above.

Gaseous Fuels derived from processing of crude oil, petroleum or petrochemicals: There was not a consensus in the BWG on adding this to the definition of natural gas. The Petroleum Environmental Research Forum Project 92-19 (PERF data) found no significant difference in air toxic emissions between burning natural gas, as defined above, and these process derived gaseous fuels. Enclosed in Appendix 1 there is a paper entitled "Rationale for Broad Definition of Gaseous Fuels" which supports the argument of incorporating Gaseous fuels derived from processing of crude oil, petroleum or petrochemicals into the definition of Natural Gas.

However, at this time, because of not being able to review and digest the information, the BWG did not come to consensus on this definition and is deferring the decision of the incorporation of these process derived gaseous fuels with natural gas to the EPA.

2.1.3 Oils:

Oils can be divided into two categories:

- Distillate Oil (also called unheated oil): Fuel oils that comply with the specifications for fuel oil numbers 1 and 2, as defined by the American Society of Testing and Material in ASTM D396-78, Standard Specifications for Fuel Oil. (40 CFR 60.41 b)

- Residual Oil (also called heated oil): Crude oil, and all fuel oil numbers 4,5, and 6 as defined by the American Society of Testing and Materials in ASTM D-396-78, Standard Specifications for Fuel Oils. (40 CFR 60.41 b)

2.1.4 Coal: The coal definition is the same as that from 40 CFR 60.41b (NSPS Subpart Db) – Coal means all solid fuels classified as anthracite, bituminous, sub-bituminous, or lignite by the American Society of Testing and Materials in ASTM D388-77, Standard Specification for Classification of Coals by Rank, coal refuse, and petroleum coke. Coal-derived synthetic fuels, including but not limited to solvent refined coal, gasified coal; coal-oil mixtures are also included in this definition.

2.2 Subcategorization

The Boiler Work Group established subcategories for fossil fuel fired boilers to incorporate factors that may affect the HAP emissions from those units and/or the viability of control techniques that may reduce HAP emissions from those units. The work group determined that the fuel type and firing method are the key factors that affect HAP emissions and the viability of controls.

Gas, oil and coal were initially divided into categories due to the nature of constituents making up the fuel type and their method of handling. For instance gas is primarily methane, hydrogen, carbon and oxygen. However, coal may contain metals and more complex hydrocarbons. Coal is burned in a different manner than either gas or oils. Therefore, it was determined to initially separate these three fuel types.

Further discussion of the rationale for subcategorization is provided in the sections below:

2.2.1 Gas Fired Systems: Gas fired systems were left as a single subcategory for several reasons. The first was based on the overall emissions from those types of boilers. The emissions on all types of gas fired boilers, although variable, were generally very low. Second, the controls on boilers generally were not designed to control HAP emissions. Third and perhaps most important is that the burner design on gas fired systems is essentially the same for various types of gas fired boilers. It consists of an air and gas mixing system. The burner is designed to guarantee adequate mixing for good stoichiometric combustion.

2.2.2 Distillate Oil Fired Systems: Distillate Oil systems were likewise left as a single subcategory for essentially the same reasons as gas fired systems. The oils are atomized in the burner in several manners (air, steam or mechanical). The purpose of atomization, no matter what the method, is to better mix the fuel with the air. It was assumed, like gas, that distillate oil because of the similarity of the fuel mixing burners and the effectiveness of the burners, that combustion characteristics and therefore the HAPs emissions should not be appreciably noticeable between boiler types within the Distillate Oil fired category.

2.2.3 Residual Oil Fired Systems: All residual oils or heavy oils (No. 4 and above) are generally heated prior to introduction in to the burner. Residual oils, like distillate oils use the atomization method for injection of the fuel into the firing chamber. Because of similar firing designs among oil burners, they were left as a single category.

2.2.4 Coal:

2.2.4.1 Solid Fossil Fuels (Coal)

The ASTM fuel types were chosen for the further subcategorization. Petroleum coke was also included as a fuel type. Fuel types vary by their carbon content and other factors like moisture content, ash content, and BTU content to name a few. All of these factors effect boiler design and can affect HAP formation and emissions

ASTM Standard D388 - 77 is entitled “Standard Classification of Coals by Rank.” The main ranks of coal in this standard are anthracite, bituminous, subbituminous, and lignite. Each of these major ranks is broken down into at least two sub-ranks. The boiler workgroup believes that there is no need to break the ranks into the sub-ranks for subcategories. Fuels are ranked by carbon content if the carbon content is greater that 69% and by BTU content for all other fuels. Carbon content is generally inversely proportional to volatile content. This factor plays a key role in boiler size (e.g., larger for higher volatility) and configuration.

.
Coal refuse means any by-product of coal mining or coal cleaning operations with an ash content greater than 50 percent (by weight) and a heating value less than 6,000 Btu per pound (Btu/lb) on a dry basis.

Petroleum Coke is a carbonaceous solid produced from coal, petroleum, or other materials by thermal decomposition.

Many other factors effect boiler design and vary with fuel type. These include ash content and ash characteristics, and moisture content. All of these factors are taken into account when sizing a boiler and designing the heat transfer surfaces. As the design changes to accommodate the differences in the fuel, many things in the boiler change including the temperature profile which could effect HAP formation and emission rates. The boiler designs established for subcategories are the following: pulverized coal/cyclone, mass fired, fluidized bed.

2.2.4.2 Solid Fuel Boiler Types

Solid fossil fuels were also subdivided into boiler types. Three main boiler types were determined to be appropriate for the subcategories. The types are fluidized bed boilers, mass feed or stoker boilers, and pulverized coal or cyclone boilers. Each of these boilers has a unique firing system that could result in different HAP emissions.

Many factors must be considered during boiler design. One of the main factors is where and how the fuel is introduced into the furnace. This main factor lead to the decision by the boiler workgroup to first subcategorizes by boiler types. The types are fluidized bed boilers, mass fired / stoker boilers, and pulverized / cyclone boilers.

Each boiler type that was identified for subcategorization has a different firing system. Pulverized and cyclone boilers fire the fuel in suspension while in mass fired boilers some portion of the combustion takes place on the furnace floor on a grate. The fluidized bed boilers burn fuel in an aerated mass with limestone. Each of these firing types leads to different temperatures of combustion and boiler temperature profiles that can result in different HAP formation and emission rates.

Pulverized Coal/Cyclone

Pulverized coal boilers burn coal in suspension by pulverizing the coal and injecting it into the boiler with a transport air stream. In general, a low percentage of ash drops out as bottom ash (approximately 20%), with the remainder passing through the boiler as flyash, dropping out in hoppers or particulate collection devices. Pulverized coal fired boilers can be dry bottom or wet bottom. Wet bottom boilers operate at a higher furnace temperature and use coal with properties that allow a portion of ash to be removed from the furnace in the molten state. Dry bottom boilers operate at a lower temperature and use coal with properties, which do not create molten slag in the furnace. While there could be differences in HAP emissions from dry bottom vs wet bottom boilers; there is not adequate data on which to differentiate between those designs for MACT floor purposes.

Cyclone boilers burn crushed coal in cyclones prior to entering the boiler furnace. The cyclones operate at a high temperature, which allows a significant quantity of ash to be removed in the molten state.

In general, HAP emission rates are believed to be similar for pulverized coal and cyclone boilers for MACT floor purposes.

Mass Fired

Mass fired boilers include mass feed stokers, spreader stokers, and underfeed stokers. These types of boilers are characterized by the use of larger sized coal (about 2x0 top size) wherein most of the coal is burned on the grate. This feature results in most of the coal ash being removed as bottom ash (at least 80%), with the remainder passing through the furnace as flyash, dropping out in hoppers or particulate collection devices. Some stoker-fired boilers also reinject cinders or flyash into the furnace in order to reduce unburned carbon losses. Excess air levels in general are higher for mass fired boilers vs pulverized coal/cyclone units due to the greater difficulty in obtaining proper fuel/air mixing with mass fired units.

Fluidized Bed

Fluidized bed boilers operate with either a bubbling bed or circulating bed. In both cases, the upward velocity of air through the bed causes a suspension of the fuel and inert matter or limestone. Circulating fluid bed units operate with a high furnace velocity, which entrains particulates and allows recirculation back into the bed for increased carbon burnout.

An important design parameter is the type of fuel in combination with the boiler type. As an example, a bituminous stoker is designed much differently than a pulverized bituminous unit. The result could be different HAP emissions from the same fuel. All of the above reasons lead to the subcategories being established based on firing type in combination with fuel type.

3. Approach and Rationale for MACT Floors.

3.1 General Approach to MACT Floor Analysis

The BWG decided to make some basic assumptions in order to determine the MACT floor. These assumptions are as follows:

- First, this is a preliminary MACT Floor determination for these fossil fuels. This is by no means a final review since testing has not been performed and the data is still being analyzed.
- The categories are based on fuel type (gas, liquid and solid) and the subcategories are broken out as described above.
- The data used for the MACT floor determination for controls is the EPA Boiler Inventory Database Version 3.0.
- The data that was reviewed for this preliminary MACT floor determination was from the dataset that specified control/abatement information or indicated no control. That is, all of those units on the database that did not specify control information were left out of this round of MACT floor determinations. This makes the data more conservative than if all the units were used.
- The requirements of Section 112 (d) of the 1990 CAA specify that for 30 sources or more in a category, MACT will be the average emission limitation achieved by the *best performing 12 percent* of existing sources in the category (*for which the administrator has emissions information).* It was determined by the BWG for gas and oil fired systems the average of the "best performing 12 percent" would be the top 6 percent of the controlled systems. Anything below 6 percent would not be considered for the MACT floor.
- The units considered here burn only fossil fuels.
- The emissions database, state air regulations and permits information along with the RACT/BACT/LAER information would be reviewed to determine if there was enough information to determine a floor or to set potential HAP emission limits.
- The databases would be reviewed from a GCP and P2 perspective to determine if a MACT floor could be discerned from the data.

3.2 Available Data Information for the MACT Floor

3.2.1 ICCR Boiler Population Database

3.2.1.1 Gas Information

Version 3 of the EPA Boiler Database contained a total of 42,582 gas fired boilers. In the analysis of those boilers only 18,321 boilers had control or abatement information. The rest of the boilers did not specify any control information. There were only 177 boilers or about 0.97 % that indicated applicable add-on controls which would be considered to impact HAP emissions.

Because this was well below the 6 percent limit set by the BWG, it was determined that there was NO MACT FLOOR for Gas Fired Boilers.

Pollution Prevention (P2) and Good Combustion Practices (GCP) will be discussed below.

3.2.1.2 Distillate Oil Information

In Version 3 of the EPA Boiler Database there were 6604 boilers in the distillate (unheated) oil category.   Of that, only 2623 boilers had control or abatement information or indicated that there were no controls. Seventy (70) boilers or 2.68% of the indicating boilers had controls of some sort.

Because this was well below the 6 percent limit set by the BWG, it was determined that there was NO MACT FLOOR for Distillate Oil Fired Boilers. GCP and P2 will be discussed below.

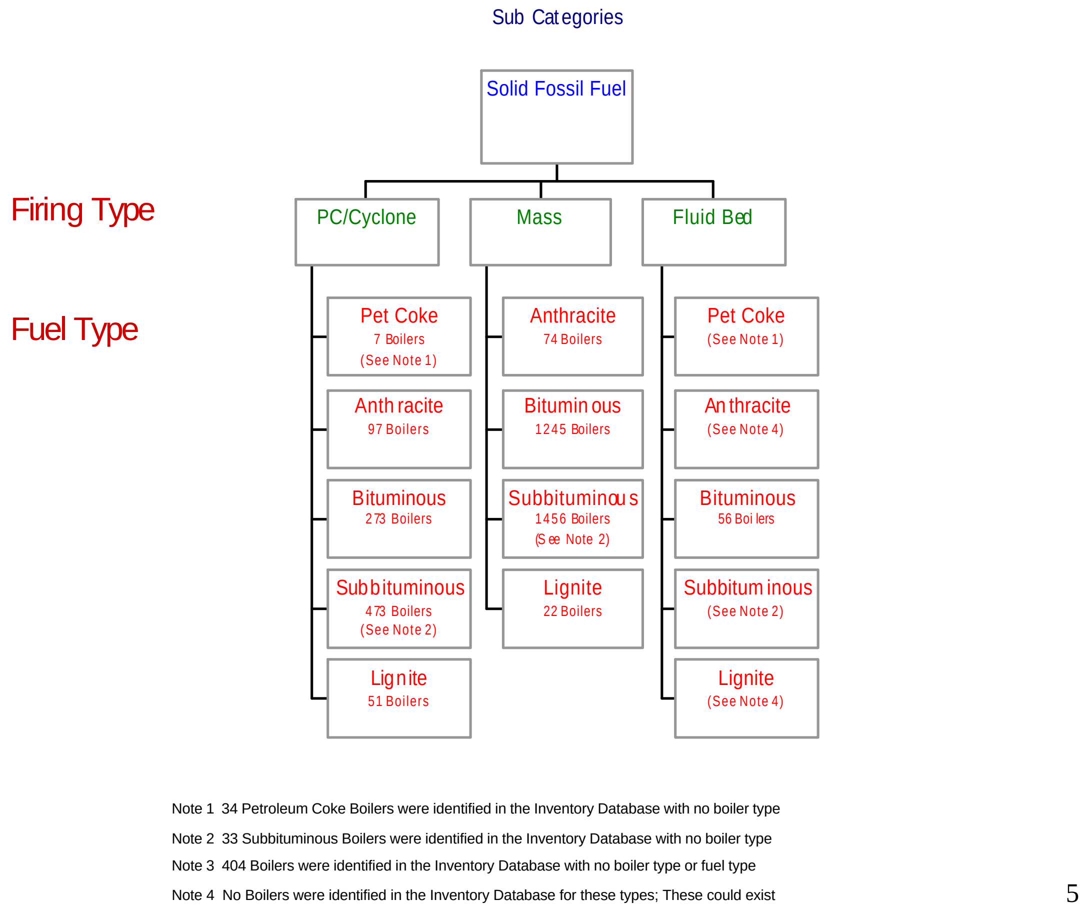
3.2.1.3 Residual Oil

Version 3 of the EPA Boiler Database has 7945 boilers residual or heated oil boilers. Of those, 4810 boilers had control or abatement information. Only 264 boilers or 5.50 % had applicable add-on controls.

Again, because this level of add-on controls was less that the predetermined 6 percent cutoff, there is NO MACT FLOOR for Residual Oil Fired Boilers.   GCP and P2 will be discussed below.

3.2.1.4 Coal

Figure 1: Coal Fired Subcategories



At this time, no determinations have been made for the MACT floor for any of the boiler types listed above.

3.2.2 ICCR Boiler Emissions Database

The Boiler Work Group reviewed the ICCR Emissions Database to determine if the emissions data from gas- and oil-fired boilers could be used for MACT floor. Based on a review of the available emissions information, the Boiler Work Group determined that the existing emissions data are inadequate to identify a best performing group of existing boilers and to identify achievable emission limitations for existing boilers.

3.2.2.1 Gas Boiler Emissions Database Information

The ICCR Emissions Database for boilers fired with gas includes over 20 air emission test reports for HAPs. Gas-fired boilers in the database range in size from 2 MMBtu/hr to 7,500 MMBtu/hr heat input, or from less than 1 MW to750 MW. The test reports represent tests conducted on 50+ boilers (as compared to over 40,000 gas-fired boilers in the ICCR Inventory Database). The database includes data from few boilers in the industrial sector (e.g., oil and refining), but mostly from very large boilers in the utility sector. A large majority of the source tests were conducted in the State of California as part of the AB2588 (Air Toxics "Hot Spots" Information Assessment Act of 1987) program.

The HAP emissions information in the ICCR Emissions Database for gas-fired boilers is very limited. In addition, nearly all of the emissions information is from very large boilers in the utility industry. The Boiler Work Group determined that this information may not be representative of emissions of gas-fired boilers that are in the commercial/institutional/industrial boilers source category due to differences in design, control equipment, and operational practices.

The Boiler Work Group noted the deficiencies in the ICCR Emissions Database for possible MACT control techniques. There is no data to evaluate control efficiencies.

The Boiler Work Group also noted that the HAP emission levels for gas-fired boilers reported in the ICCR Emissions Database are variable. For example, formaldehyde and benzene levels for gas-fired boilers cover two-to-three orders of magnitude. This is consistent with the recent American Petroleum Institute study titled "Emissions Variability on Boilers"(Appendix 2) that discusses this variability. The study states that, "The variability in the ICCR emissions database arises from the inherent variability in the combustion and measurement processes. This variability is magnified in the field due to differences in sampling and analytical methods, to differences in design, operational parameters, and location, as well as the level of data quality assurance screening."

3.2.2.2 Conclusions from Oil Emissions Database Information

The Boiler Work Group reviewed the ICCR Emissions Database for oil fired boilers to determine if the emissions data could be used for the MACT floor determination. Based on a review of this information, the work group determined that the existing emissions data are inadequate to identify a best performing group of existing boilers and to identify achievable emission limitations for existing boilers. The actual test reports were not completely reviewed, but analysis of the emissions database provides the following insights:

- Many “Fuel Oil” fuel type units, which are generally interpreted as distillate oil fired units, are fired with residual oil as indicated by the fuel data information.

- Some of the boilers are identified as being originally designed for coal firing and tested while firing oil. This leads to incorrect interpretation of controls which are applied to oil fired boilers.

- In some cases, it is noted that where particulate collection devices are installed, they were not in operation during the emission tests. Other tests did not indicate whether this was the case or not.

- Most of the emissions test data is from electric utility units and not from industrial boilers. While HAP emissions from utility units could be similar to industrial units, that is not an indication of what equipment is installed on industrial boilers.

- Much critical data is not listed in the database or indicated as “Not Provided.”

- There are orders of magnitude differences in HAP emission rates from different runs and tests on the same unit with no other apparent differences in operation or other data to indicate a cause for the variation. This leads to a conclusion of inherent variability in HAP emission rates and an inability to establish an emission rate suitable for MACT floor determination.

- Many HAP emissions are truly a function of the fuel properties. No fuel data is provided.

- There is conflicting information in the database with no explanation, e.g., “No Equipment” vs the comment information.

- Some test data is from a very small boiler with uncharacteristically high excess air levels and is not indicative of typical industrial boilers.

There is no consistency of data and an inadequate number of data points upon which to establish a MACT floor.

3.2.2.3 Conclusions from Coal Emissions Database Information

Version 3 of the Emissions Database contains information from 255 sites or conditions for coal fired units. Some sites were tested under different conditions, like before and after air pollution control devices. The 255 tests resulted in 6550 stack tests for individual parameters. In other words, about 25 parameters were identified per site / condition.

The database is mostly from the work done in the report to Congress entitled "Study of Hazardous Air Pollutant Emissions from Electric Steam Generating Units - Final Report to Congress". This study was done for larger utility sources but the data should be comparable to ICCR coal sources. Other database sources were from AP42 information and from STIRS.

The database is difficult to interpret due to the number of abatement device combinations. In order for the database to be used for rulemaking the subcategories must be defined and then the database be sorted by the subcategories and then by the abatement devices. These steps will be tedious since much of the information in the database fields do not provide enough information to easily sort items such as abatement equipment.

3.2.3 State Air Regulations and Air Permit Limits for HAPs

For the purpose of MACT floor, the Boiler Work Group limited its review of State air regulations and air permit limits to HAPs only. Although some States regulate air emissions of volatile organic compounds (VOCs) from existing boilers, and some HAPs are VOCs, the control of VOCs does not necessarily indicate control of HAPs. Similarly, although some States regulate air emissions of particulate matter (PM) from existing oil-fired boilers, and some HAPs are PM, the control of PM does not necessarily indicate control of HAPs. Therefore, the Boiler Work Group concluded that VOC and PM emission limitations are insufficient, at this time, to be used as the basis for HAP emission limitations for gas and oil-fired boilers.

Available information on state air regulations and air permit limits for HAPs was obtained from
The following sources:

- State regulations obtained by members of the Boiler Work Group
- RACT/BACT/LAER Databases, and
- permit limit information in the ICCR Population Database for Boilers.

The Work Group's findings on state air regulations for HAPs are presented in **Section 3.2.3.1** of this report. The findings on air permit limitations for HAPs are presented in **Section 3.2.3.3** of this report.

3.2.3.1 State Regulations

Members of the Boiler Work Group contacted State, local, and regional air pollution control agencies and obtained copies of their regulations for boilers. Members also developed a survey form that was sent to agencies that requested specific information on emission limits and controls. The results of the survey responses and the information in the regulations were summarized into several tables for use in this analysis.

Based on a review of information obtained by members of the Work Group, the Boiler Work Group was unable to identify any state air emission regulations that establish specific emission limitations for HAP emissions from natural gas-fired or fuel oil-fired boilers. Time did not allow a sufficient review of coal fired boilers.

3.2.3.2 RACT/BACT/LAER Databases

The RACT/BACT/LAER Clearinghouse contains information from air permits submitted by most of the state and local air pollution control programs in the United States. The database is available on-line at the TTN web site of the EPA:

http://www.epa.gov/ttn/catc

in the CATC (Clean Air Technology) technical site

Emissions limits for boilers were searched by downloading all available databases (historical, transient, and current) of the RACT/BACT/LAER Clearinghouse. The historical, transient, and current RACT/BACT/LAER databases were searched individually for state air permit limitations for boilers. Information was obtained on 15 fuel oil fired boilers out of 14,510 total in the inventory database. HAP permit limits were reported for at least one of the following pollutants: Arsenic, Beryllium, Bromine, Cadmium, Chromium, Copper, Formaldehyde, Lead, Manganese, Mercury, Nickel, Polycyclic Organic Materials (POMs), Selenium, and Vanadium. No HAP permit limits were identified for natural gas-fired boilers.

3.2.3.3 Permit Limit Information

Version 3 of the ICCR Population Database includes HAPs air permit limits for 17 gas-fired boilers, out of 42,582 total gas-fired boilers, and no fuel oil-fired boilers out of 14,510 total fuel oil-fired boilers. HAP permit limits are reported for at least one of the following pollutants: Benzene, Chlorine, Ethylbenzene, Formaldehyde, Hydrogen chloride, Toluene, and Vinyl chloride.

Permit limits were identified for boilers in both the RACT/BACT/LAER database and the inventory database. The Boiler Work Group determined that these permit limits should not be used as the basis for MACT floor since:

1. There was insufficient information in the ICCR Population Database to allow the Boiler Work Group to properly subcategorize the units.

2. It is unclear whether the permit limitations are based on emissions testing or on the use of emission factors, such as AP-42.
3. The 17 fuel oil-fired boilers and 17 natural gas-fired boilers represent less than 0.2 percent of fuel oil-fired boilers and less than 0.05 percent of the natural gas-fired boilers in the ICCR inventory database.

3.3 Emission Control Techniques

Good Combustion Practices (GCP) which could potentially impact organic HAP emissions are discussed under the Good Combustion Practices section.

The Boiler Work Group assessed possible emissions control techniques which could impact HAP emissions from gas and oil fired boilers.

3.3.1 Gas Fired Boilers

The inventory database indicates a low percentage of gaseous fired boilers being equipped with controls which could reduce mercury, inorganic HAP, and metal emissions. However, that data has not been verified at this time, and it is believed that those indicated units are designed for some fuel other than natural gas. There is no knowledge within the work group of situations where add-on controls are used on gas fired boilers. Based on the data reviewed, the Boiler Work Group concluded that no MACT Floor could be established on the basis of emissions control techniques.

3.3.2 Distillate (Unheated) Oil Fired Boilers

The inventory database for distillate oil fired boilers was reviewed by ERG and determined that there are very few add-on controls which could reduce mercury, inorganic HAP, and metal emissions for distillate oil fired boilers. It is believed that some, if not all of those indicated boiler controls are associated with another fuel rather than distillate oil. (For example, 0.46% of units with ESP’s, 0.69% with cyclones, 0.04% with gas absorbers, 0.04% with activated carbon adsorption). Based on the data reviewed, the Boiler Work Group concluded that no MACT Floor could be established on the basis of emissions control techniques.

3.3.3 Heated (residual) Oil Fired Boilers

The inventory database indicates a low percentage of residual oil fired boilers being equipped with controls which could reduce mercury, inorganic HAP, and metal emissions. However, that data has not been verified at this time, and it is believed that many of those indicated units are designed for some fuel other than residual oil. There are some residual oil fired boilers which have SO2 scrubbers installed, and those do provide some HAP emission reductions. However, they are a small percentage of total (0.69%) prior to verification of the database. Based on the data reviewed, the Boiler Work Group concluded that no MACT Floor could be established on the basis of emissions control techniques.

3.4 Good Combustion Practices for Oil and Gas Fired Boilers

The Boiler Work Group assessed good combustion practices for gas and oil fired boilers by (1) researching and reviewing possible good combustion practices for the purpose of HAP reduction from boilers and (2) assessing the prevalence of those practices by reviewing information available in the ICCR Population database, information from state air permitting authorities, and the expertise of Work Group members.

Based on the information review thus far and the discussion below, the Boiler Work Group has tentatively concluded that no good combustion practices should be included in the MACT Floor for existing gas or oil fired boilers.

Possible Good Combustion Practices Include:

3.4.1 Gas Fired Boilers

3.4.1.1 Fuel/air ratio control

For use by the Economics Subgroup, several possible GCP practices were identified for gaseous fuels. Those included practices, which controlled fuel/air ratio by various methods and were assumed to provide possible minor reductions in organic HAPs. Some gas fuel fired boilers were identified to have GCP in the Inventory Database, but only a very low number (0.43%). There was no data in the emissions database, which could be used to quantify any HAP emissions reduction associated with those practices. The PERF test report found no significant difference in HAP emissions with any additional fuel/air controls over those routinely employed by boilers. All existing boilers must use fuel/air ratio controls of some sort to comply with existing safety and air permit requirements. Based on the information review thus far and the above discussion, the Boiler Work Group has tentatively concluded that establishing GCP based on fuel/air ratio control as part of the MACT Floor is not recommended. However, there were some differing opinions on the ability of fuel to air ratio to help control HAP emissions (see Sect. 3.6).

3.4.1.2 Maintenance practices

Poor maintenance practices of boilers could possibly lead to deterioration of unit efficiency and incomplete fuel combustion, which could lead to, increased HAP emissions. However, existing economic drivers and existing permit requirements force attention to proper maintenance. Maintenance practices can also vary significantly depending on the design and operating characteristics of individual boilers. There is also no data available in the inventory or emissions database upon which to base any quantification of HAP emissions impact based on levels of maintenance. Since maintenance practices are highly variable, it is not practical to quantify the impact of maintenance practices on HAP emissions. Based on the information review thus far and the above discussion, the Boiler Work Group has tentatively concluded that establishing GCP based on maintenance practices as part of the MACT Floor is not recommended. However, some in the BWG were of the opinion that Maintenance Practices may help curb HAP emissions (see Sect. 3.6).

3.4.1.3 State Regulations

EPA has recently summarized data from state regulations relative to practices that could be considered GCP. These summary tables indicate on a gross basis the number of boilers that may be required to implement the practices. However, it is recognized that the number of units is inflated over the actual number due to an inability to differentiate the actual number of boilers in the inventory database which are required to meet those requirements, since they are directed at specific locations, heat input capacities, and other limiting criteria. Thus, the number of boilers impacted is likely to be much lower than indicated in the tables. Conversely, there may be additional local requirements which may not be captured in the present tabulations. Additional efforts would be needed to enable any conclusions from that data.

However, some observations could be obtained from the state data. First, the boilers subject to these practices are doing so as part of ozone nonattainment programs targeting NOx emission reductions, not HAP emission requirements. Second, there are boiler size applicability limits to many of the practice requirements, and that would greatly influence the number of units impacted. There is also no information relative to the HAP emission impact of any of the practices. Based on the information review thus far and the above discussion, the Boiler Work Group has tentatively concluded that establishing GCP based on state regulations as part of the MACT Floor is not recommended. Additionally, there were some in the BWG that thought that not all the state regulations had been reviewed adequately to determine if they set rules that might control HAP emissions (see Sect. 3.6).

3.4.2 Oil Fired Boilers

3.4.2.1 Fuel/air ratio control

For use by the Economics Subgroup, several possible GCP practices were identified for liquid fuels. Those included practices that controlled fuel/air ratio by various methods and were assumed to provide possible minor reductions in organic HAPs. Some oil fired boilers were identified to have GCP in the Inventory Database, but only a very low number (0.99% for distillate oil or 0.34% for residual oil). There was no data in the emissions database that could be used to quantify any HAP emissions reduction associated with those practices. All existing boilers must use fuel/air ratio controls of some sort to comply with existing safety and air permit requirements. Based on the information review thus far and the above discussion, the Boiler Work Group has tentatively concluded that establishing GCP based on fuel/air ratio control as part of the MACT Floor is not recommended. See Section 3.6 for differing opinions by some BWG members.

3.4.2.2 Maintenance practices

Poor maintenance practices of boilers could possibly lead to deterioration of unit efficiency and incomplete fuel combustion that could lead to increased HAP emissions. However, existing economic drivers and existing permit requirements force attention to proper maintenance. Maintenance practices can also vary significantly depending on the design and operating characteristics of individual boilers. There is also no data available in the inventory or emissions database upon which to base any quantification of HAP emissions impact based on levels of maintenance. Since maintenance practices are highly variable, it is not practical to quantify the impact of maintenance practices on HAP emissions. Based on the information review thus far and the above discussion, the Boiler Work Group has tentatively concluded that establishing GCP based on maintenance practices as part of the MACT Floor is not recommended. See Section 3.6 for other opinions regarding maintenance practices and HAP emissions control.

3.4.2.3 State Regulations

EPA has recently summarized data from state regulations relative to practices that could be considered GCP. These summary tables indicate on a gross basis the number of boilers which may be required to implement the practices. However, it is recognized that the number of units is inflated over the actual number due to an inability to differentiate the actual number of boilers in the inventory database which are required to meet those requirements, since they are directed at specific locations, heat input capacities, and other limiting criteria. Thus, the number of boilers impacted is likely to be much lower than indicated in the tables. Conversely, there may be additional local requirements that may not be captured in the present tabulations. Additional efforts would be needed to enable any conclusions from that data.

However, some observations could be obtained from the state data. First, the boilers subject to these practices are doing so as part of ozone nonattainment programs targeting NOx emission reductions, not HAP emission requirements. Second, there are boiler size applicability limits to many of the practice requirements, and that would greatly influence the number of units impacted. There is also no information relative to the HAP emission impact of any of the practices. Based on the information review thus far and the above discussion, the Boiler Work Group has tentatively concluded that establishing GCP based on state regulations as part of the MACT Floor is not recommended. See Section 3.6 regarding the opinions of some BWG members that HAP emissions may be coincidentally controlled by some state imposed rules.

3.5 Pollution Prevention (P2)

3.5.1 Boiler Efficiency Considerations

As noted above, boiler efficiency could be related to HAP emissions on the basis of increased fuel input requirements in order to meet output demands. However, it is extremely difficult to establish a MACT Floor which could include consideration of efficiency in any way except as a compliance alternative to a MACT numerical standard as discussed in the P2 subgroup documents. The inherent efficiency of every boiler is unique, and the ability to influence that efficiency is limited by many technical, economic, and operational considerations. The inherent boiler efficiency varies as a function of boiler load and many other conditions. Therefore, while this could be further considered, based on available information and the expertise of the Boiler Work Group, it is not recommended to include boiler efficiency provisions as part of the MACT Floor. See Section 3.6 below for an alternative opinion regarding HAP control and boiler efficiency.

3.6 Other GCP/P2 Considerations

Consensus was not reached in the BWG regarding NO MACT FLOOR based on GCP or P2. It was perceived by some in the BWG that perhaps there were some GCP or P2 practices that coincidentally controlled HAPs. There was no time to investigate this although several technical experts disagreed because there was no data to support such an argument. There were also some arguments regarding good operating efficiencies reducing the amount of fuel needing to be burned and thus reducing HAPs.

4.0 HAP Emission Limit Considerations

4.1 Emissions from ICCR Emissions Database

As stated above in Section 3.2.2, ICCR Boiler Emissions Database, there were no discernible specific limits identified for HAPs emissions in the review of the ICCR Emissions Database. Therefore, there are no recommendations for HAP emission limits.

4.2 State Air Emission Regulations for HAPs

As stated above in Section 3.2.3, State Air Regulations and Air Permit Limits Databases, there were no discernible specific limits identified for HAPs emissions from the review of the state air regulations. Therefore, there are no recommendations for HAP emission limits.

4.3 Air Permit Limitations for HAPs

As stated above in Section 3.2.3, State Air Regulations and Air Permit Limits Databases, there were no discernible specific limits identified for HAPs emissions from the review of the air permits. Therefore, there are no recommendations for HAP emission limits.

5.0 Conclusions:

By consensus the BWG has set the following subcategories for fossil fuels:

- Natural Gas - which includes wellhead gas, pipeline gas, liquified petroleum gas (LPG).
- Distillate Oil
- Residual Oil
- Coal with the additional subcategories by fuel type of anthracite, lignite, bituminous petroleum coke and sub bituminous. Within these fuel types are the following types of boiler design: pulverized coal/cyclone, mass fired, fluidized bed.

It should be noted that although arguments are presented in this document for including gaseous fuels derived from processing of crude oil, petroleum or petrochemicals in the definition of natural gas, consensus was never reached on the issue.

Once the subcategories were established the various databases were reviewed to determine the MACT floor and to help set HAP emission limits for natural gas, distillate oil and residual oil. Time expired on the ICCR FACA process and a review for coal was not completed.

After a review of the inventory database, the emission database, the state regulation and permit databases and the RACT/BACT/LAER databases there was no data that indicated a MACT Control requirement or a clear HAP emission limit.

The review of Good Combustion Practices did not indicate specific GCP requirements that a MACT floor could be established on. However, there was concern by some members of the BWG that further investigation may indicate that some GCP, not initially defined as HAP controls may coincidentally be abating HAPs.

Therefore, with all of the above reviews that were performed and based on the subcategorization and assumptions that were made, there was a conclusion NO MACT Floor can be identified at this time for oil and gas. Coal will have to be further studied to determine its MACT Floor. It was further concluded that there are no HAP emission limits associated with this MACT Floor.

It is now recommended that the Coordinating Committee of the ICCR FACA forward these determinations and associated rationale to the EPA.

Appendix 1: Boilers Working Group - MACT Floor Documentation

Rationale for Broad Definition of Gaseous Fuels

Boilers Working Group - MACT Floor Documentation
Rationale for Broad Definition of Gaseous Fuels

Background

Emissions data on HAPs and criteria pollutants used in the MACT determination process originated from several sources, and have gone through several stages of screening and assessment, as described in the Boilers Working Group "HAPs of Interest Analysis". For gas-fired external combustion devices (i.e. Boilers and Process Heaters) three primary sources were utilized.

First, source test results collected under the California Air Toxics "Hot Spots" Inventory and Assessment Act (AB2588) have been compiled and quality reviewed in a joint effort by the Western States Petroleum Association (WSPA), the California Air Resources Board (CARB), and the American Petroleum Institute (API). The results of this investigation are compiled in the 3-volume Draft Report titled "Development of Toxics Emission Factors for Petroleum Industrial Combustion Sources" (D. W. Hansell and G. C. England, EER Corporation, September 1997). It was provided to the US EPA in October 1997, and is available in the ICCR docket. A presentation on this database was provided to a joint meeting of all the ICCR Work Group members on November 18, 1997. The validation and verification processes used to quality assure these data makes this the most reliable and comprehensive compilation of field emission source test data for petroleum industry combustion sources. The final report is currently being printed by API (August 1998) and will be available to the Coordinating Committee and the US EPA by mid-September.

The second source of emissions test data came from the Petroleum Environmental Research Forum (PERF) 92-19 "Toxic Combustion Byproducts" project. In 1992 PERF initiated a Cooperative Research and Development Agreement (CRADA) with the U.S. Department of Energy, and with EPA participation, performed an experimental and fundamental investigation of chemical and physical mechanisms governing organic HAP formation, destruction, and emissions. These tests on full-scale burners were performed at the Sandia National Laboratories/Livermore. This program produced data of very high quality that shed light on many of the key questions surrounding the field data. The results of this project were presented to the Coordinating Committee on July 22, 1997, and are summarized in a paper titled "Organic Hazardous Air Pollutant Emissions from Gas-Fired Boilers and Process Heaters" (G.C. England and D.W.Hansell, EER Corporation, July 1997) which is available in the ICCR docket. The PERF 92-19 CRADA Final Report, "The Origin and Fate of Toxic Combustion Byproducts in Refinery Heaters: Research to Enable Efficient Compliance with the Clean Air Act" (August 5, 1997), and be accessed at http://www.epa.gov/ttn/iccr/dirss/perfrept.pdf. The complete 10-volume study including test reports and appendices has been placed in the ICCR docket.

Lastly, the ICCR Emissions Database, V.2, provides a compilation of emissions test data made available from existing electronic databases such as STIRS, and other information from state and local agencies. Emissions information collected from the 114 ICR survey was also added to this database.

Conclusions

Based on the discussion above and the references cited therein, we conclude that:

- ***HAP emissions from all gas-fired sources are generally very low, but exhibit inherent variability associated with process fluctuations and sampling and analysis uncertainties*.**

  The PERF data referenced above demonstrate that HAP emissions from typical industry gas fired burners, under a variety of operating conditions are all very low, at or near the detection limits of the best measurement methods. In addition, field source test data, such as the WSPA/API database indicate that annual total HAP emissions from operating gas-fired heaters and boilers are well below the major source definition.

- ***HAP emissions from devices fired by either natural gas or petroleum processing derived gas are similar, on a Btu basis.***

  The controlled laboratory testing (PERF study) and the WSPA/API field test data demonstrate that emissions factors derived independently for different gaseous fuels are indistinguishable, when measurement uncertainty and process variability are taken into account (Figures 1). The emission factor derivation process accounts for the different heat content of the variety of the gases used in practice, and which like natural gas, consist primarily of hydrocarbons mixtures.

- ***HAP emissions from gas-fired boilers and process heaters are equivalent*.**

  Design practices are such that the same burner types are used for constructing both gas-fired process heaters and boilers. In addition, the field emissions data for boilers and process heaters, fired by a variety of gaseous and liquid fuels, was shown to be similar (Figure 2). The data demonstrate that emissions from boilers or process heaters vary by size (heat input) but are otherwise expected to be equivalent.

Recommendations

For the purposes of subcategorizing boilers – it is recommended that a single subcategory be established for devices firing the following gaseous fuels:

1. *Natural Gas/Wellhead Gas:* a naturally occurring mixture of hydrocarbon and non-hydrocarbon gases found in geologic formations beneath the earth's surface, of which the principal constituent is methane;
2. *Liquid Petroleum Gas:* as defined by the American Society of Testing and Materials in ASTM D1835-82, Standard Specification for Liquid Petroleum gases.
3. *Petroleum Derived Gas:* Gaseous fuel derived from the processing of crude oil, petroleum, or petrochemicals.

Since consistent definitions of the fuels combusted are desirable for all ICCR sources, we recommend that the Coordinating Committee adopt the three-part definition above which is consistent with that adopted by both the Process Heaters and Turbines Working Groups for their gaseous fired devices.

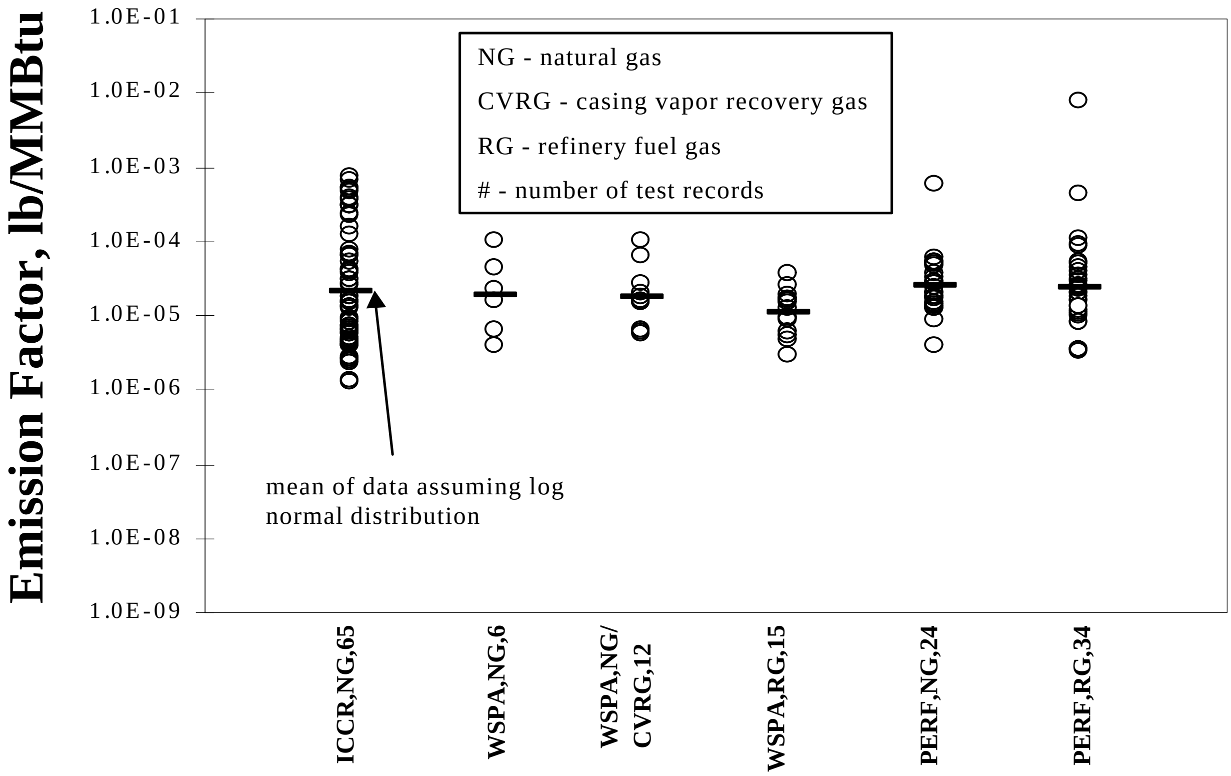
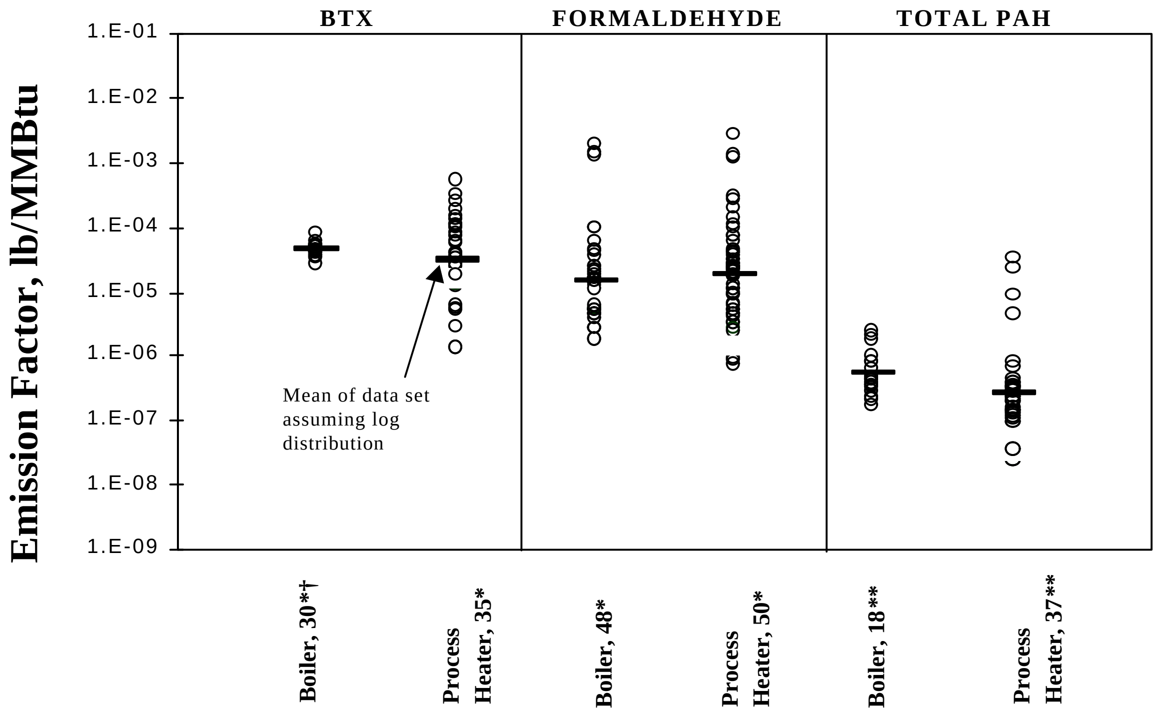


Figure 1. Formaldehyde emissions as a function of fuel type for gas fuel fired boilers (ICCR, WSPA, and PERF data).



* Includes crude, FO #6, and gaseous fuel (primarily gas)

** Includes FO #6 and gaseous fuel (primarily gas)

† Number following label = number of test records

Figure 2. Comparison of HAP emissions data for Boilers and Process Heaters (WSPA data).

APPENDIX 2

EMISSIONS VARABILITY ON BOILERS

Emissions Variability for Boilers

Conclusion: Considerable variability is observed in the reported emissions of HAPs from similar sources firing similar fuels under similar operating conditions. This level of variability is not uncommon in databases of this type and is to be expected when searching for trace emissions at the limits of detection. The variability in the ICCR emissions database arises from the inherent variability in the combustion and measurement processes. This variability is magnified in the field due to differences in sampling and analytical methods, to differences in design, operational parameters, and location, as well as the level of data quality assurance screening.

When analyzing the boiler emissions information in the ICCR database, one observes that there is considerable variability in the reported emissions of hazardous air pollutants from similar sources firing similar fuels under similar operating conditions. When looking at any process, there is a natural variability that is inherent to both the process and the device used to measure the process. The vast majority of this variability is most likely due to sampling and analytical errors. Some small portion of the variability may be due to minor differences in the design, operation, and geographic location of the combustion devices.

An instructive demonstration of this inherent variability can be found in the PERF 92-19 study. As shown in Figure 2-1, variability of up to two orders of magnitude can exist even in situations where the combustion device, the measurement techniques, and the operating parameters are highly standardized. This exceedingly high quality data illustrates what might be called the “irreducible minimum” or “inherent” variability that is unavoidable when searching for trace HAP emissions at the limit of detection of the most sophisticated of sampling and analytical methods.

The PERF HAPs emission data were collected at the Sandia National Laboratory, Livermore, California, Combustion Research Facility’s Burner Engineering Research Laboratory (BERL), a 2.0 MMBtu/hr test facility for full-scale industrial burners. Before and after each of the five different full-scale commercial burner test sequences, “Regulatory Base Case” repetitions were carried out to make sure that nothing in the physical setup had changed in the interim between sequences nor over the period of days required to complete a given test sequence. While this was done primarily to make sure that “the same” system was being tested each time, this procedure of Regulatory Base Case repetition provides the concomitant benefit of demonstrating the irreducible minimum data variability for trace HAPs.

The PERF “Regulatory Base Cases” characterized normal operation at 2 MMBtu/hr at a stoichiometric ratio of 1.25 (*i.e.,* 25% excess air) and furnace exit temperature 1600F firing either refinery fuel gas, the “A1” cases, or natural gas, the “A4” cases. The Regulatory Base Case “A1” fuel was a mixture of 16%

hydrogen in natural gas plus propane to yield 1050 Btu/scf heating value while the Regulatory Base Case “A4” was pure natural gas with the same heating value of 1050 Btu/scf. Thus the Regulatory Base Case fuel mixtures, heating value, burner load, stoichiometric ratio and furnace exit temperature were all duplicated at each repetition as nearly as possible and in strict conformance with the highest EPA QA/QC protocols. The PERF 92-19 CRADA’s Quality Assurance Project Plan, acknowledged by EPA as one of the best they have ever seen, guaranteed data of regulatory development quality.

As the sampling, analytical, and operating conditions at the BERL were more tightly controlled than would be possible in a field facility, the data from this study provides a benchmark for HAP emissions data variability. For example, one test team, on the same combustion device, using the same sampling and analytical methods conducted at the same laboratories collected all of the data. Yet even under these highly controlled conditions, substantial “inherent” HAP emissions data variability was observed.

This inherent variability that is observed even under the most controlled situations is magnified and added to in the field by many other sources of variability. These sources include differences in sampling and analytical procedures, detection limits, sample volumes, analytical accuracy and precision requirements, lab contamination, data reporting requirements, different sampling contractors, data reduction and data entry errors, etc. Many of these variables are listed in Table 2-1, which shows selected HAPs sampling and analytical procedures, detection limits, and acceptable analytical accuracy and precision requirements. As Table 2-1 illustrates, accuracy errors and imprecisions of up to 50% are allowed by many methods. These allowances will contribute to variability in measurements.

Another factor that impacts variability is the level of data quality assurance screening. The U.S. EPA has procedures for addressing low sensitivity, non-detect data and determining and eliminating outliers. For example, the WSPA/API/CARB database has undergone such a screening, which has to some extent lowered the overall variability. The ICCR Emissions Database has not undergone such a screening procedure.

To a much lesser extent, differences in boiler design, in the process operating conditions, and even in the location of combustion systems can contribute to the emissions data variability. For example, operational parameters such as swings in process feed rates and in load changes brought about by interactions with other processes could impact the variability. A combustion system located in a hot, humid climate may be operated differently than a system in a cold, dry climate. Differences can even be expected based upon changes in season i.e. between winter and summer.

Even if each of these many different aspects by themselves contribute only a small percentage of the overall variability, together they can add up to orders-of-magnitude differences in the measured emissions across the population of sources as observed in this MACT determination analysis. Lastly, it should be mentioned that a quantitative assessment of the relative contribution of the various factors discussed in the Section is not possible based on the information available in the ICCR databases.

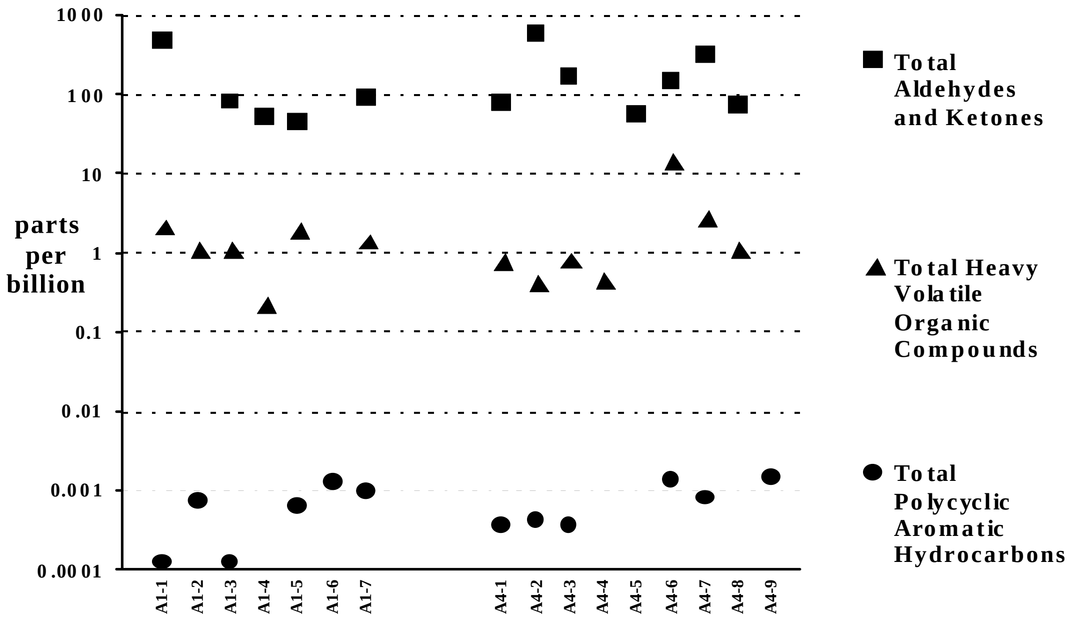


Figure 2-1. PERF 92-19 CRADA Regulatory Base Case Repetitions Illustrate Irreducible Minimum Variability when Searching for Trace Emissions at the Limit of Detection

TABLE 2-1

SELECTED HAPs SAMPLING AND ANALYTICAL PROCEDURES AND DETECTION LIMITS

HAP	Sampling & Analytical Method(s)	Sampling Procedure	Analytical Procedure	Detection Limit (ng/dscm) (1)	Detection Limit (lb/MMBtu) (2)	Analytical Precision (%)	Analytical Accuracy (%)
PAH - Benzo(a)pyrene	CARB 429	Isokinetic with XAD-2 resin	HRGC/HRMS	5	2.7E-09	+/- 50	50-150
PAH - Benzo(a)pyrene	CARB 429	Isokinetic with XAD-2 resin	HRGC/LRMS	100	5.4E-08	+/- 50	50-150
PAH - Benzo(a)pyrene	EPA SW-846 M0010/ EPA SW-846 M8270	Isokinetic with XAD-2 resin	LRGC/LRMS	1,000	5.4E-07	+/- 50	50-150
Formaldehyde		Hot wet extraction	FTIR	120,000	6.8E-05		
Formaldehyde	CARB 430	Non-isokinetic with DNPH Impingers	HPLC	10,000	5.4E-06	+/- 10	70-130
Formaldehyde	EPA SW-846 M0011/ EPA SW-846 M8315	Isokinetic with DNPH Impingers	HPLC	800	4.4E-07		
Benzene	EPA SW-846 M0030/ EPA SW-846 M5040	Non-isokinetic with Tenax Resin	GC/MS	1,000	5.4E-07	+/- 50	50-150
Benzene	EPA Method 18	Non-isokinetic with Tedlar Bag	GC/PID/ECD	160,000	8.8E-05	+/- 5	90-110
Benzene	CARB 410A	Non-isokinetic with Tedlar Bag	GC/PID	11,000	5.8E-06	+/- 5	90-110
Benzene	CARB 410A	Non-isokinetic with Tedlar Bag	GC/FID/PID	3,200	1.8E-06	+/- 5	90-110
Benzene	EPA SW-846 M0040/EPA TO-15	Non-isokinetic with Tedlar Bag	GC/MS	1,600	8.8E-07	+/- 25	70-130
Benzene			FTIR	320,000	1.8E-04		
PCDD/PCDF-2,3,7,8-TCDD	EPA Method 23	Isokinetic with XAD-2 resin	HRGC/HRMS	0.005	2.7E-12		
PCDD/PCDF-2,3,7,8-TCDD	CARB 428	Isokinetic with XAD-2 resin	HRGC/HRMS	0.005	2.7E-12	+/- 30	60 - 140
PCDD/PCDF-2,3,7,8-TCDD	EPA SW-846 M0010/ EPA SW-846 M8290	Isokinetic with XAD-2 resin	HRGC/HRMS	0.05	2.7E-11		

PCDD/PCDF-2,3,7,8-TCDD	EPA SW-846 M0010/ EPA SW-846 M8280	Isokinetic with XAD-2 resin	HRGC/LR MS	50	2.7E-08		

In databases such as those used in the ICCR, the analytical procedure is the parameter that can be expected to have a large impact on the emissions variability. This is due to the fact that non-detect data are generally reported as either the full or one-half the detection limit. Thus, units with emissions below detectable levels will have very different reported emissions if they are tested by two methods with different detection limits.

For example, the detection limit for the polycyclic aromatic hydrocarbon benzo(a)pyrene is a factor of 200 lower if the sample is analyzed using high resolution gas chromatography (GC)/high resolution mass spectrometry (MS) rather than low resolution GC/low resolution MS. Therefore, if two similar sources are tested for benzo (a) pyrene, one using the high resolution technique and the other using the low resolution technique, and benzo (a) pyrene is not detected in either sample, the reported emissions will be 200 times higher for the source tested with the low resolution technique even if all other sources of variability are equivalent. Both techniques are valid, however the low-resolution technique is less expensive.